Ice Seasonality Investigation
Lake Ice Glossary

pages

It is important to keep in mind that even moderately sized ponds rarely freeze to the bottom. Even during the coldest part of the winter there is some water below the ice at the deepest parts of the pond.

Some Key Concepts and Terms

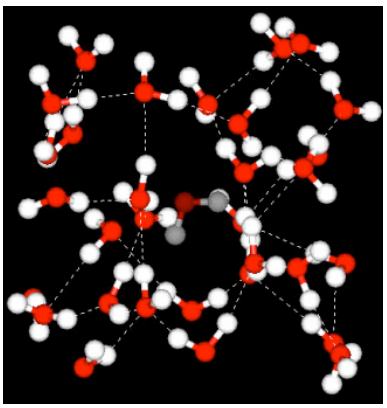
Some Properties of Water
Water can exist in any one of three states: solid (ice), liquid (water) and gas (water vapor).

Fresh water has a maximum density at around 4°C: 1 g cm^3, 1 g ml^{-1}, 1 kg $liter^{-1}$, 1000 kg m^3, or 1 tonne m^3.

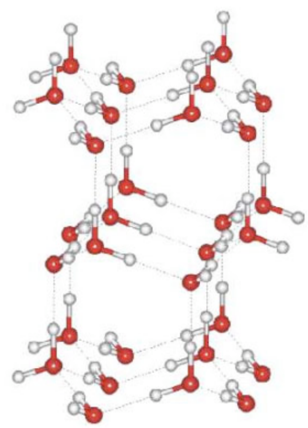
Water is the only substance where the maximum density does not occur when solidified (which is why ice floats on water)..

Solid water (ice) is the most ordered (least energetic) state of water while gas is the least ordered (highest energetic) state.

Water Phase Change



Liquid water can be thought of as a seething mass of H_2O molecules in which hydrogen-bonded clusters are continually forming, breaking apart, and re-forming. The more crowded and jumbled arrangement in liquid water can be sustained only by the greater amount thermal energy available above the freezing point (0°C).
(Source:
http://ssrl.slac.stanford.edu/nilssongroup/pages/project_liquid_structure.html)

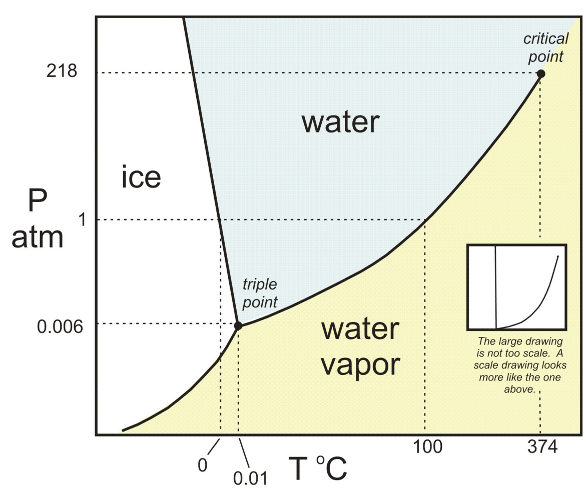


Notice the *greater openness* of the ice structure. This is necessary to ensure the strongest degree of hydrogen bonding in a uniform, extended crystal lattice. (Source: http://ssrl.slac.stanford.edu/nilssongroup/pages/project_liquid_structure.html)

A **phase change** is a change from one state to another without a change in chemical composition. These changes are induced by the effects of temperature and/or pressure:

The transitions are:
Solid-to-liquid transition - *melting*
Liquid-to-solid transition - *freezing*
Liquid-to-gas transition - *evaporation*
Gas-to-liquid transition - *condensation*
Solid-to-gas transition - *sublimation*
Gas-to-solid transition - *deposition*

(Source:
http://serc.carleton.edu/NAGTWorkshops/petrology/teaching_activities_table_contents.html)



Energy, Temperature and Heat
Energy is defined as the capacity to do work (the amount of work one system is doing on another). There are two kinds of energy that are of interest here:
- Internal energy is defined as the energy associated with the random, disordered motion of molecules; it refers to the invisible microscopic energy on the atomic and molecular scale
- Kinetic energy is energy of motion. The kinetic energy of an object is the energy it possesses because of its motion.

Temperature measures the average kinetic energy of the particles in a substance. It measures the degree of heat (high energy) or cool (low energy) of a substance. Heat is defined as energy in transit.

Heat (internal energy) moves from a **high** temperature region to a **low** temperature region. This is called heat transfer.

Heat Transfer

Latent Heat
Latent heat is the energy required to change a substance from one state to another at constant temperature.

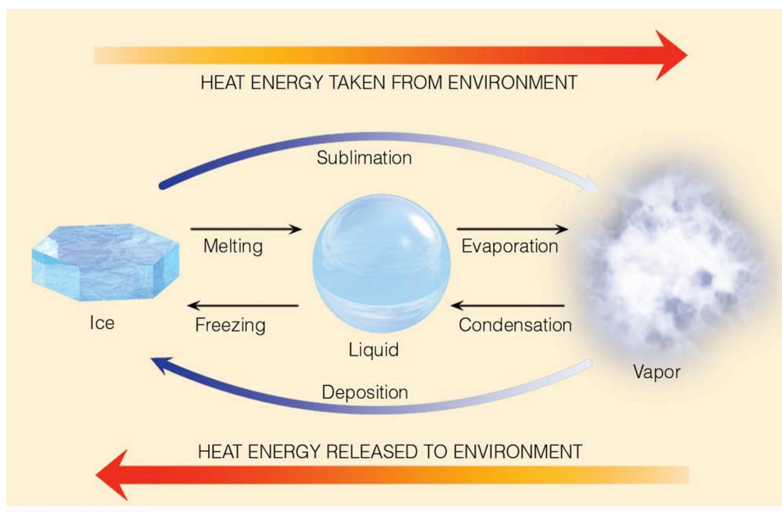
When a substance changes from one state to another, latent heat is <u>added</u> or <u>released</u> in the process.

LIQUID to VAPOR
Latent heat of evaporation is **taken** from the environment (about 540 cal per gram)

VAPOR to LIQUID
Latent heat of condensation is **released** to the environment

LIQUID to ICE
Latent heat of freezing is **released** to the environment (about 80 cal per gram)

ICE to LIQUID
Latent heat of fusion (melting) is **taken** from the environment

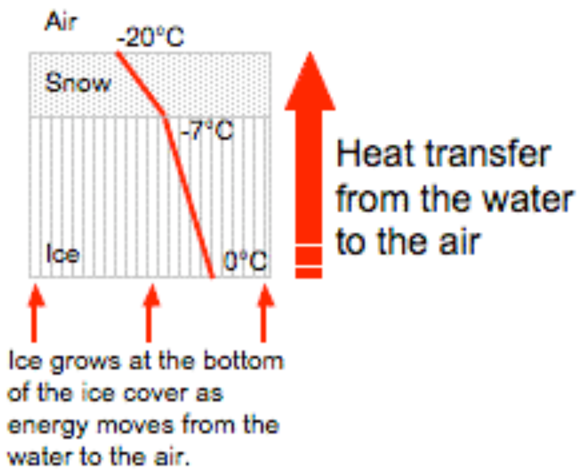


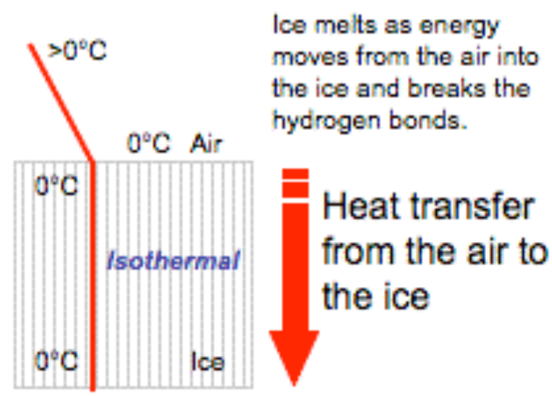
(Source: http://apollo.lsc.vsc.edu/classes/met130/notes/chapter2/lat_heat2.html)

Latent Heat of Freezing and Melting

The **latent heat of freezing** is the energy released from the water and added to the environment, in order for water to freeze into ice. When heat is subtracted from liquid water, the individual water molecules will slow down. They eventually slow to the point at which the hydrogen bonds do not allow the liquid to rotate anymore. Ice now develops. (Source: http://www.theweatherprediction.com/habyhints/19/)

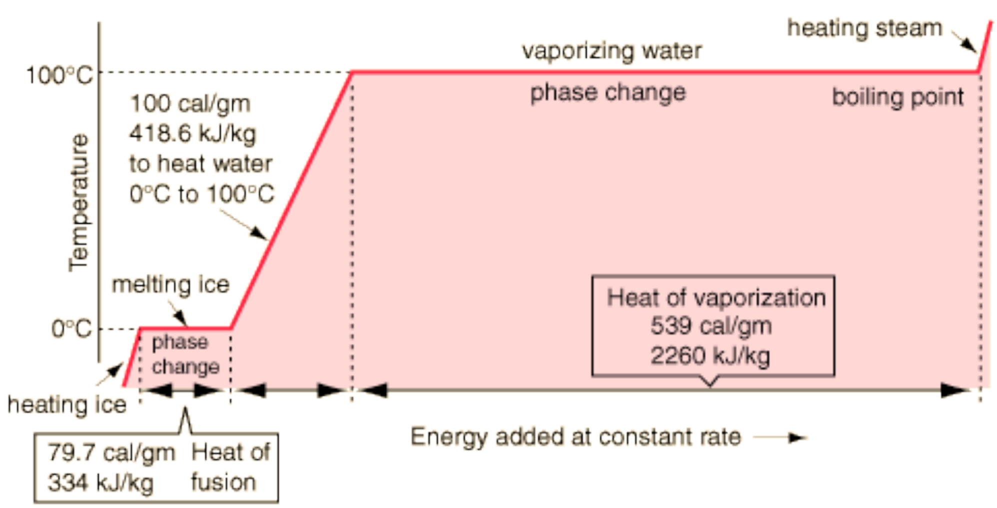
The **latent heat of fusion (melting)** is the energy that is taken from the environment and added to the ice to melt it into water. This energy is used to break the ice lattice bonds and allows the ice to go from a lower energetic state to a more energetic state (water). (Source: http://www.theweatherprediction.com/habyhints/19/)





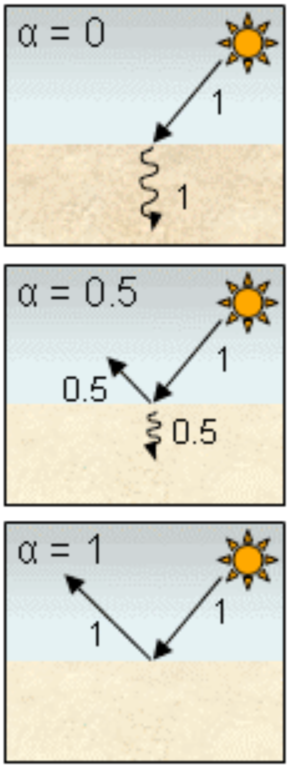
When water undergoes a phase change (a change from solid, liquid or gas to another phase) the temperature of the water stays the same. Energy is being used to either weaken the hydrogen bonds between water molecules or energy is being taken away from the water, which tightens the hydrogen bonds. When ice melts, energy is being taken from the environment and absorbed into the ice to loosen the hydrogen bonds. The temperature of the melting ice however stays the same until all the ice is melted. All hydrogen bonds must be broken from the solid state before energy can be used to increase the water's temperature.
(Source: http://www.theweatherprediction.com/habyhints/19/)

If heat were added at a constant rate to a mass of ice to take it through its phase changes to liquid water and then to steam, the energies required to accomplish the phase changes (the latent heat of fusion and latent heat of vaporization) would lead to plateaus in the temperature vs time graph.



(Source: http://hyperphysics.phy-astr.gsu.edu/Hbase/thermo/phase.html#c1)

Albedo



(Source: National Snow and Ice Data Center)

Albedo is a measure of reflectivity of a surface or body. It is the ratio of electromagnetic radiation (EM radiation) reflected to the amount incident upon it. The fraction, usually expressed as a percentage from 0% to 100% (or as a dimensionless value between 0 and 1), is an important concept in climatology and astronomy.

A **perfect absorber** does not reflect any of the sunlight that strikes it. It looks black and has an albedo of 0. When an object absorbs most of the light that hits it, it looks dark and has a low albedo.

A **perfect reflector** reflects all the sunlight that strikes it. It looks white and has an albedo of 1. Objects that reflect most of the light that hit them appear bright and have a high albedo.

Albedo Values for Common Earth Surfaces

Surface	Albedo
Absolute black surface	0.0
Forest	0.05-0.2
Water	0.06
Grassland and cropland	0.1-0.25
Dark colored soil surface	0.1-0.2
Dry sandy soil	0.25-0.45
Dry clay soil	0.15-0.35
Sand	0.2-0.4
Mean albedo of the Earth	0.36
Granite	0.3-0.35
Glacial Ice	0.3-0.4
Light colored soil surfaces	0.4-0.5
Dry salt cover	0.5
Tops of clouds	0.6-0.9
Fresh, deep snow	0.9
Absolute white surface	1.0

Lake Freeze-up

Freeze-up is the seasonal formation of a continuous ice cover on a body of water. An ice cover is a layer of ice on top of some other feature, usually the surface of a lake or pond (but also rivers and seas/oceans).
(Source: http://amsglossary.allenpress.com/glossary/).

Meteorological factors such as air temperature, precipitation, wind speed and radiation balance coupled with physical characteristics of the lakes and ice (lake area, depth, volume and fetch (the distance of open water over which the wind blows); snow depth; ice thickness, type and albedo) lead to complex interactions and feedbacks that affect the timing of freeze-up and break-up (ice cover duration) each year.

New Ice

A **thermal ice cover** grows when ice crystals form on the surface and rapidly link together to create a thin ice sheet.

Sheet ice is ice formed in a "smooth" thin layer on a water surface by the coagulation of ice crystals through rapid freezing (Source: http://amsglossary.allenpress.com/glossary/). It is also defined as a smooth, continuous ice cover formed by in situ freezing or by the arrest and juxtaposition of ice floes (defined on p. 10) in a single layer (Source: CRREL). On ponds and small lakes, a complete ice cover can form overnight.

A new ice sheet that has formed overnight under clear, calm and cold weather conditions.
(Photograph: Martin Jeffries)

Individual ice crystals are visible in a new ice sheet.
(Photograph: Martin Jeffries)

Border ice is an ice sheet in the form of a long border attached to the bank or shore. It is also called shore ice.
(Source: http://www.expertglossary.com/weather/definition/border-ice).

This is the first ice to form on the lake: it grows in calm water zones. As a consequence, the border ice may appear "whiter" than the younger ice because it is thicker and may have a thin snow cover.

In the image at right, the border ice appears more opaque (yellow arrow) than the new ice cover (red arrow).

(Photograph: Martin Jeffries)

Black (congelation) and White (snow) Ice

On small lakes two kinds of ice form, black (congelation) ice and white (snow ice).

Black ice or congelation ice is ice that appears dark in color because it permits significant light transmission to the underlying water (Source: http://amsglossary.allenpress.com/glossary/).

White ice or snow ice is ice with a white appearance caused by the occurrence of bubbles within the ice. It is formed from refrozen slush**.** The bubbles increase the scattering of all wavelengths of light in contrast to the appearance of bubble-free black ice (Source: http://amsglossary.allenpress.com/glossary/).

A **temperature gradient** is the temperature difference between two points divided by the distance between those points.

Black and White Ice Formation

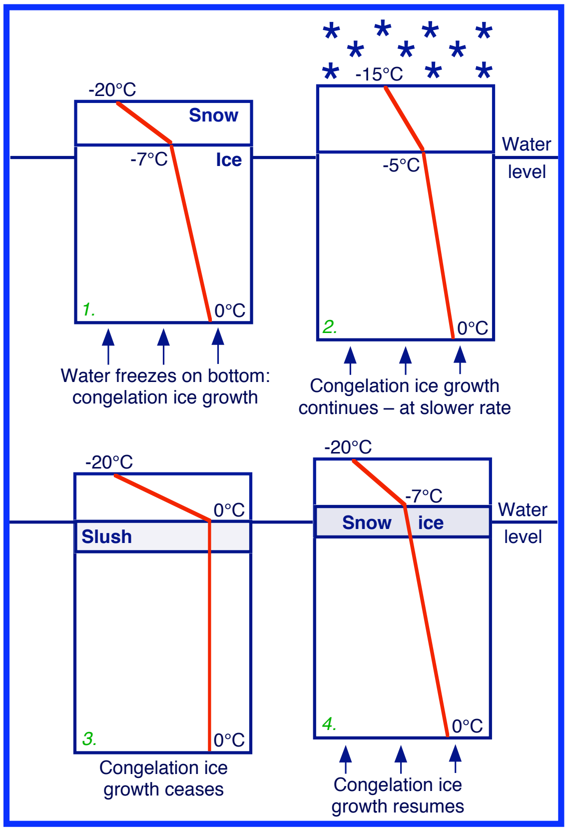
The evolution of a lake ice cover is seen in the schematic (right):

1. **Congelation** ice grows at the base of the ice cover as the latent heat of crystallization is conducted to the atmosphere through the ice and snow because there are temperature gradients.

2. Snow accumulates and congelation ice growth rates decrease because the temperature gradients decrease.

3. The snow load exceeds the buoyancy of the ice; the ice surface is depressed below water level; the base of the snow cover is soaked as water flows up through cracks in the ice; congelation ice growth ceases because there is no temperature gradient in the ice.

4. Heat conduction through the snow cover continues; the slush freezes completely to form a layer of **snow ice** on top of the ice cover; congelation ice growth resumes.



This image was acquired at 33.0 Mile Pond, AK (24 October 2004). The gray area, indicated by the arrow, is flooded snow (slush) on the ice cover. This will refreeze into ***snow ice.***
(Photograph: Martin Jeffries)

Black (congelation) and White (snow) Ice

Ice Cover and Ice Cores

The top image in this pair shows black (white arrow) and white (orange arrow) ice on MST Pond, Poker Flat Research Range, AK, early in the freeze-up season.

Ice cores were taken from a number of lakes in the spring of 2000 (bottom image). The cores have been laid out on black plastic. The white ice at the top of the ice cores (orange arrow) and black ice (white arrow) are clearly visible. (Photograph: Martin Jeffries)

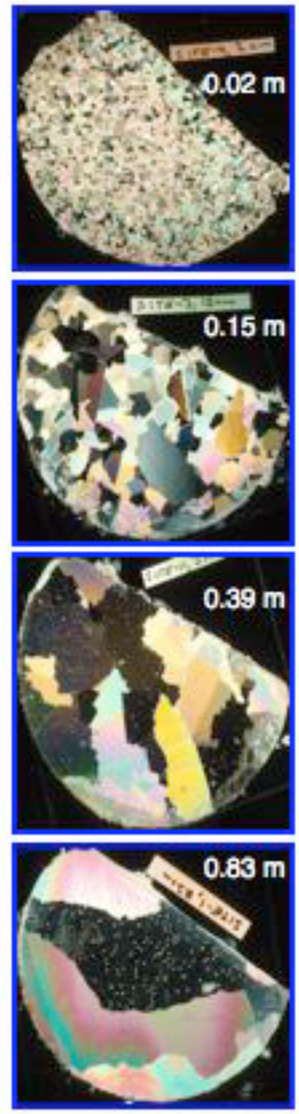
Ice cores, Poker Flat, April 2000

Thin Sections from Ice Cores

Thin sections are made by cutting ice cores vertically (below) or horizontally (right) into very thin layers. These layers allow light to pass through them. When thin sections are placed between cross-polarizing filters on a light table the, the individual ice crystals are revealed.

(Photograph: Martin Jeffries)

This vertical thin section reveals the white ice (orange arrow) at the top of the core and black ice (white arrow) at the bottom of the core. The white ice contains a large number of densely packed air bubbles and small ice crystals that cause strong light scattering. Note the column-like structure of the black ice.



(Photograph: Martin Jeffries)

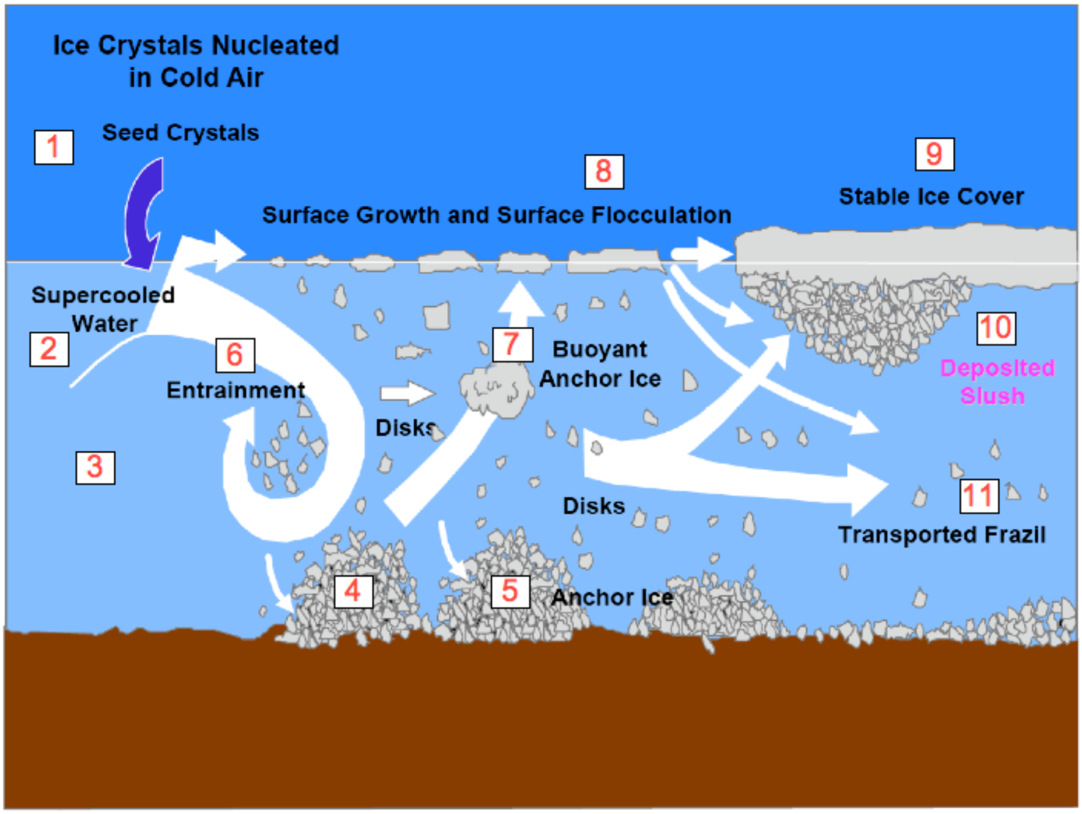
These horizontal sections show the dense crystal structure of the white ice (top) and the decreasing crystal density (or increase in crystal size) with depth of the black ice (0.15–0.83 m).

Frazil Ice

Frazil (or frazil crystals; also called needle ice) consists of ice crystals, platelets or discs, roughly 1 mm in diameter, that form in supercooled water that is too turbulent to permit the formation of sheet ice. **Supercooled water** is liquid water at a temperature below the freezing point (Source: http://amsglossary.allenpress.com/glossary/). It is the product of a very rapid rate of surface heat loss.

Frazil Ice Formation

The schematic below shows the formation and evolution of frazil.

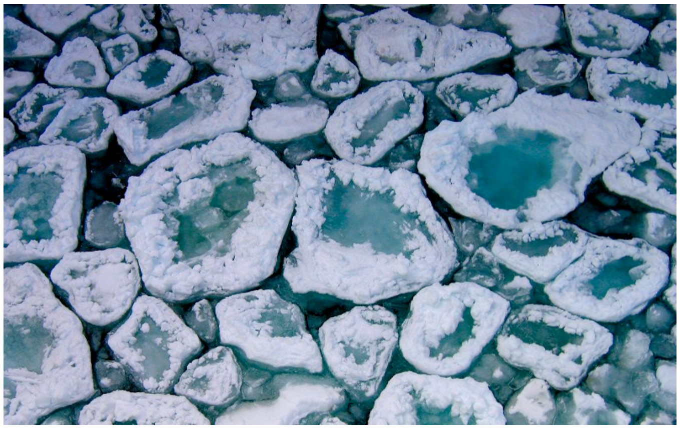


(Source: CRREL)

1) Frazil ice usually forms on clear nights when the weather is cold with air temperature ≤6°C.
2) These atmospheric conditions can lead to the formation of supercooled water.
3) Frazil crystals form spontaneously throughout the flow depth in supercooled, turbulent water.
4) Frazil crystals are so tiny that turbulent eddies in the water can carry them to the bottom. At this point in the frazil ice evolution, one of two things can happen (see 5 and 6).
5) Because the water is supercooled, frazil crystals will freeze onto any object they come into contact with and may adhere to the river bed and accumulate to form "anchor" ice.
6) Frazil crystals that are entrained (re-suspended) in the water column stick to each other to form groups of crystals, i.e., they flocculate (cluster) to form frazil slush, clusters or flocs.
7) Eventually the clusters and flocs are big and buoyant enough to overcome the water turbulence and rise to the surface.
8) The portion of the slush at the water surface, clusters and flocs freeze together to form pancakes (a few centimeters to a several meters in diameter).
9) As the water surface continues to lose some of its heat to the atmosphere, this pancake ice freezes together to form a continuous ice cover.
10) Frazil crystals can also accumulate beneath other floating ice in the river.
11) In very turbulent water, frazil crystals can be transported downstream until they encounter a barrier or the water turbulent decreases and they rise to the water surface.
(Sources: New Brunswick River Ice Manual, University of Alberta. Engineering, Frazil Ice - http://en.wikipedia.org/wiki/Frazil_ice, Hydrowiki - http://www.hydrowiki.psu.edu/wiki/index.php/Frazil_Ice)

Pancake Ice and Ice Floes

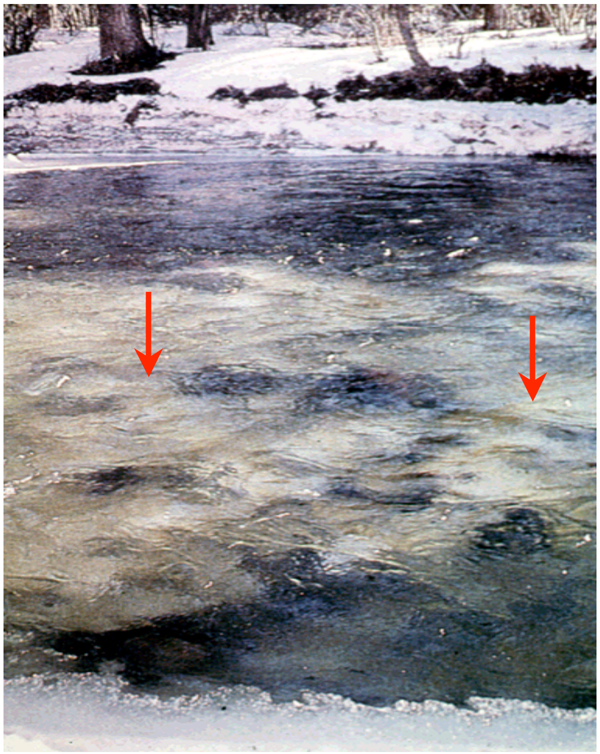
Pancake ice consists of roughly circular accumulations of frazil ice, usually less than about 3 m in diameter, with raised rims caused by collisions (Source: http://amsglossary.allenpress.com/glossary/). These can freeze together into large **ice floes**.



In large lakes, pancake ice and ice floes can form in much the same fashion as they do on the polar oceans. These are pancakes on Lake Superior.
(Source: http://www-personal.umich.edu/~jensenl/visuals/album/2006/ice/)

Some large lakes never freeze over completely, it is possible for ice floes to be driven together creating ice ridges such as on Avon Lake, OH, 12 February 2005 (red arrows). (Source: http://www.wunderground.com/)

Anchor ice visible on the riverbed during spring break-up (indicated by arrows).



(Source: CRREL River Ice guide and Glossary)

Anchor ice is ice attached to the beds of streams and lakes (*photograph at left*). It develops in supercooled water if turbulence is sufficient to maintain uniform temperature at all depths, in which case a spongy mass of frazil accumulates on objects exposed to rapid flow, and later deposition fills in the pores and creates solid ice. When the water temperature increases to above 0°C (in the spring), the ice rises to the surface, often carrying with it the object on which it had accumulated (Source: http://amsglossary.allenpress.com/glossary/).

Anchor ice mass collected from the bed of Lake Michigan, near Chicago, IL. The ice mass is formed from delicate, interlaced ice crystals and is about 40 cm in diameter.
(Source: http://faculty.gg.uwyo.edu/kempema/)

Other Features in Lake Ice

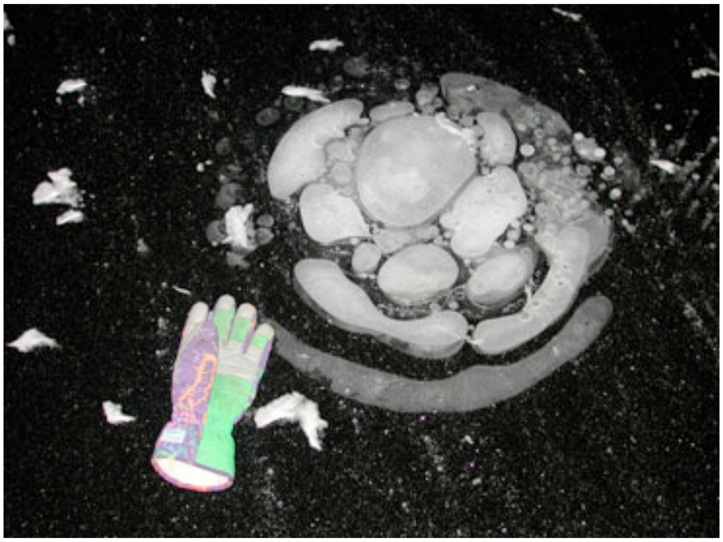
Bubbles in Lake Ice

Air (gas) bubbles in water are generated by the action of breaking waves, the impact on water of spray droplets, and by biological processes. These may freeze into the lake ice. They range in size from some centimeters down to microns. Small bubbles in particular can be carried down to considerable depths, as their limiting rise velocity is smaller than the ambient vertical water motions, and provide a significant contribution to air–sea gas flux (Source: http://amsglossary.allenpress.com/glossary/search).

Ice bubbles in the freshwater lake below Chapman Ridge
(Source: http://www.aad.gov.au/default.asp?casid=23929)

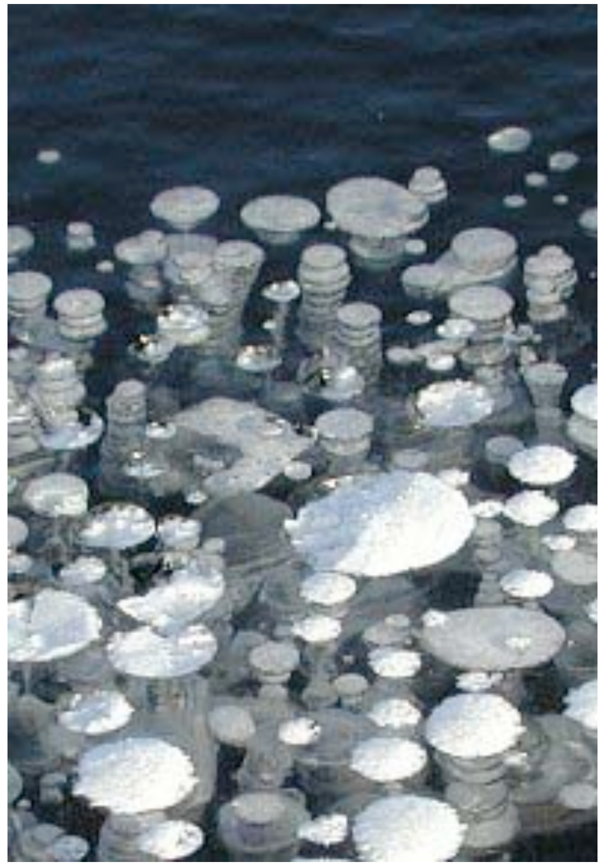
Methane Ebullition Bubbles in Lake Ice

In northern thermokarst lakes, the decomposition of vegetation and degeneration of permafrost result in methane production or release. These methane bubble rise up through the water and become trapped at the bottom of the ice cover. Eventually, ice grows around them, trapping the bubbles in the ice (examples below).



Methane bubbles trapped in lake ice in early autumn.
(Photograph: Katey Walter)

A large pocket of methane frozen in the ice of a thermokarst lake in Interior Alaska in October 2007. (Photograph: Dragos Vas, sciencedaily.com/releases/2007/09/070911092139.htm)



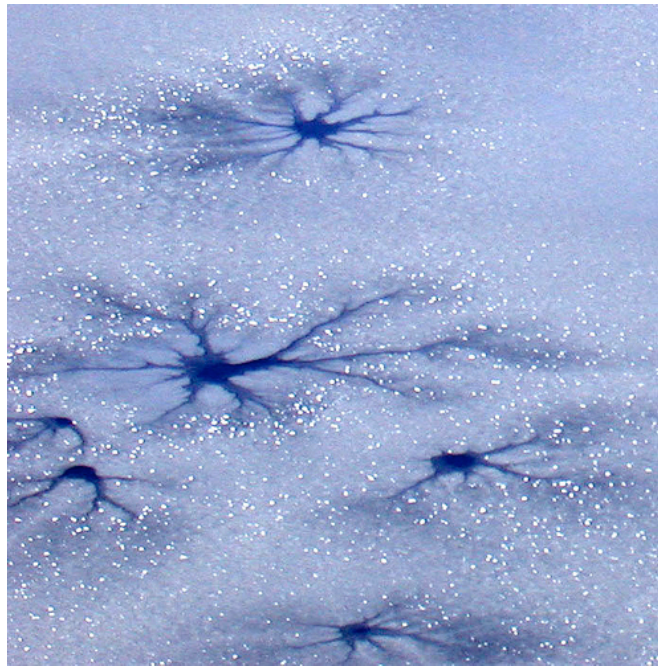
Methane bubbles trapped in lake ice in October
(Photograph: Katey Walter)

Holes in Lake Ice

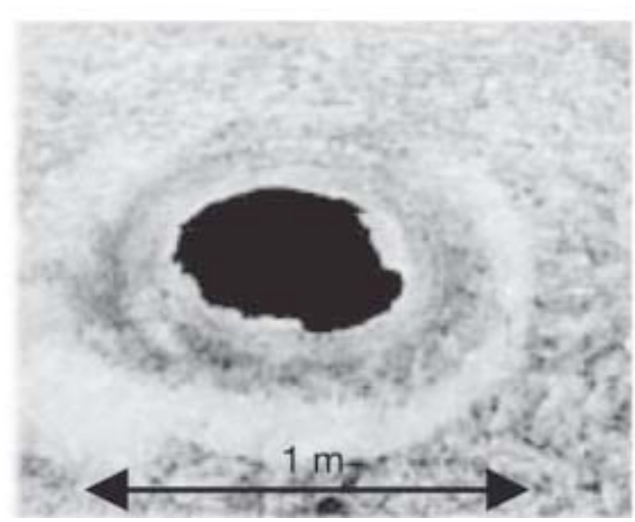
Holes can occur in ice covers at any time during the ice season. Some of these holes may be quite large and persist throughout the winter; others are small and transient.

Small holes in a very thin, new ice cover on a small pond (indicated by the arrows). These holes may simply represent the last areas to freeze over or areas where the ice has been disrupted and melted or flooded. (Image source: http://sugarmtnfarm.com/blog/2007_12_01_suarmtnfarm_archive.html)

A large open area in Lake Joutjarvi, Finland (Image source: www.panoramio.com/ photo/7123739). This open water area may be maintained by spring water flowing into the lake.



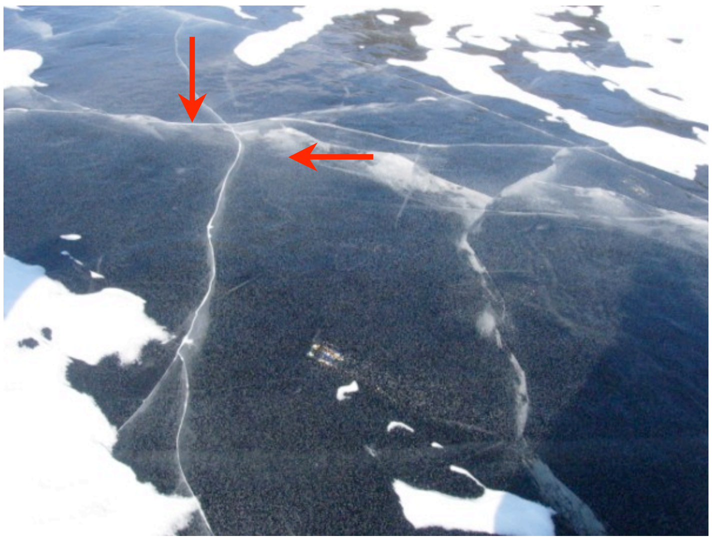
Refrozen star or spider holes on Derwent Reservoir, Derbyshire, England (4 March 2006). The cause of these features is not well understood. (Image source: http://www.flickr.com/photos/sorby/109697496/in/set-72157594181269455/)



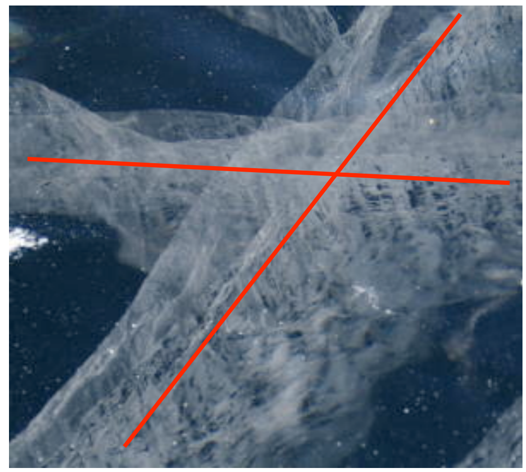
Hotspots of methane ebullition are identified as specific classes of bubble clusters or open holes in lake ice distinct from background ebullition (Photograph: Katey Walter).

Cracks in Lake Ice
A **crack** is any fracture, break or split in the ice cover that does not result in complete separation in the ice cover (Source: http://www.geo.mtu.edu/great_lakes/icegroup/ice_terms_jake.html). They can form at anytime during the ice growth and decay season.

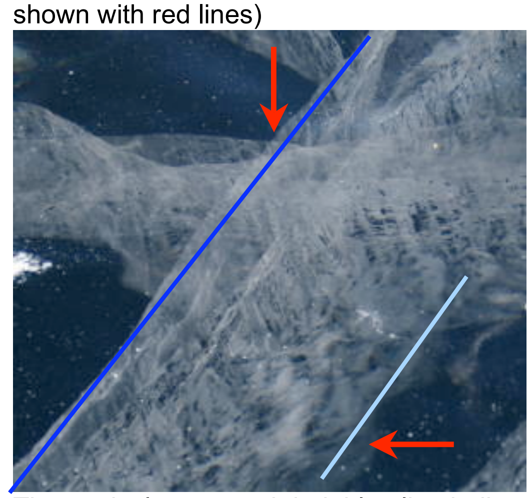
Thermal Cracks In Lake Ice
A **thermal crack** is a crack in ice cover caused by thermal contraction of the ice (Source: http://www.geo.mtu.edu/great_lakes/icegroup/ice_terms_jake.html). They form during cold nights when the ice surface cools and the bottom of the ice remains at 0°C. This causes the ice cover to become concave until it cracks. Thermal cracks open and close in response to changes in the ice temperature (Ashton, 1986). They do not necessarily extend all the way to the bottom of the ice cover, i.e., the crack does not go all the way through the ice cover.



Cracks in a black (congelation) ice cover are revealed after the snow has been redistributed by the wind. The cracks appear at the surface as strong "white" lines (vertical arrow). Because it is possible to see "into" the ice, the sides of the crack are also visible as less well defined white zones (horizontal arrow). See image at lower right. (Source: www.turtleside.com/ sutton.nh.2007-02-10.html).



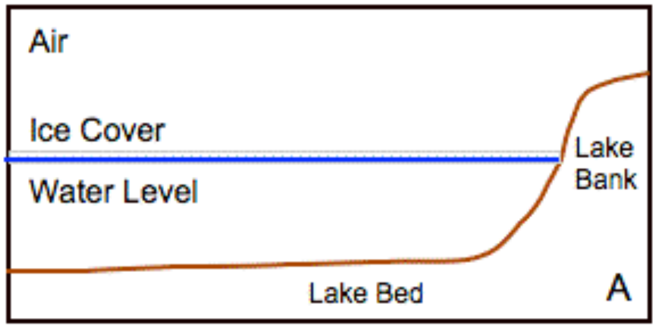
This image looks into the black ice cover in an area where two cracks intersect (general orientation shown with red lines)

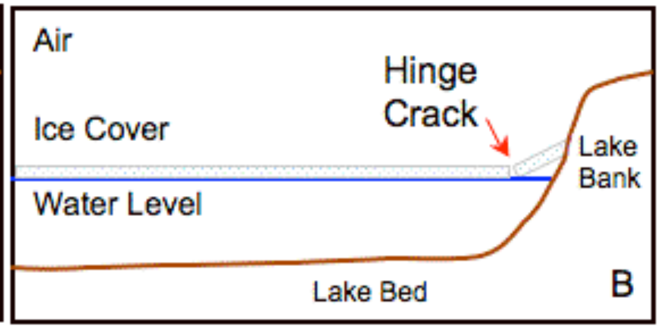


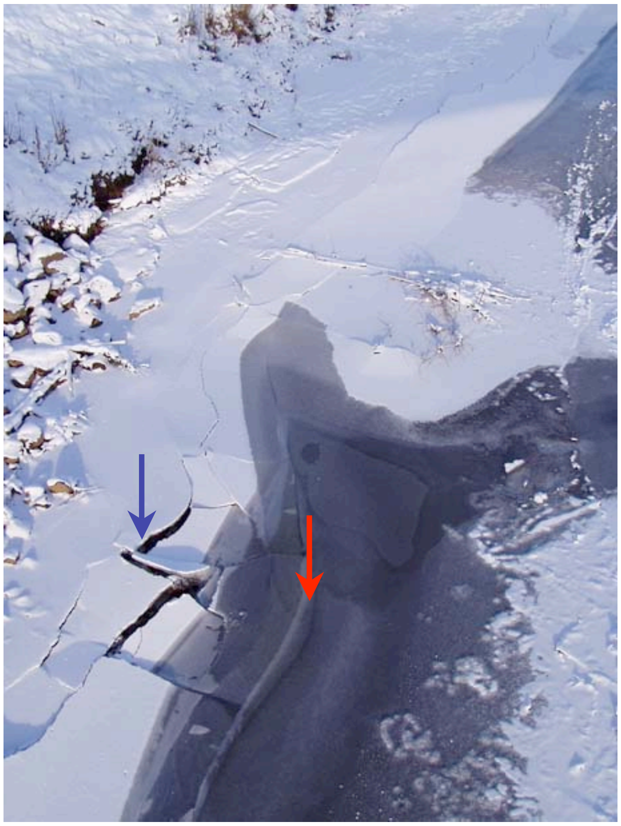
The vertical arrow and dark blue line indicate the ice surface and top of the crack. The horizontal arrow and light blue line indicate the bottom of the crack. The white zone in between the lines is the side of the crack. (Source: http://www.barrenlands.org/dispatch/April/24/index.html)

Hinge Cracks and Dropped Ice
A **hinge crack** is a crack caused by significant changes in water level (Source: http://www.expertglossary.com/weather/definition/hinge-crack). Hinge cracks can form in thin autumn ice cover.

The lake ice grows at the top of the water column and floats on top of the water (A). As the source of inflow into the lake decreases due to freeze-up of streams and precipitation falls as snow rather than rain, the level of the lake falls. . If the ice cover is not attached to the bank, i.e., free-floating, it is structurally unaffected by the decreasing lake water level. However, if the thin ice is frozen to the bank, it breaks because there is no longer any water to support it and it is to thin/weak to support the snow load. This is a hinge crack (B).






(Photograph: Martin Jeffries)

The initial, thin autumn ice cover is not very strong. This means that the ice is prone to failure when underlying water does not support it. This leads to the creation of a hinge crack. The blue arrow indicates the hinge crack in the image at left. Note how thin the ice is. The failure of the ice cover maybe sufficient to break it into pieces.

These ice pieces may become flooded (orange arrow). This could happen because the ice cover cracks but does not break and water is forced up through the cracks onto the ice forming slush on the ice surface. When breaking, the ice pieces might become wedged in the remaining ice cover in such a way that they are not “free floating” and are below the water level resulting in flooding.

Lake Ice Break-up

Lake ice break-up is the disintegration of an ice cover on land, river, or coastal waters as a result of thermal and mechanical processes. Break up of ice covering a body of water at a site; depends on ice thickness. (Source: http://amsglossary.allenpress.com/glossary/)

Snowmelt and Ponding

Break-up begins with snowmelt. This snow includes the snow on the banks of the pond and on the lake ice. **Snowmelt** is the water resulting from the melting of snow. Much of this water drains onto the lake ice cover. This melt water forms ponds on the ice cover and eventually melts through the ice or drains through cracks that develop in the ice.

Ponding on the ice occurs when this meltwater forms zones of standing water on the ice cover.

Eventually, the melt water melts through the ice or drains through cracks that develop in the ice.

A **snowmelt flood** is a substantial rise in stream or river discharge caused by snowmelt runoff (Source: http://amsglossary.allenpress.com/glossary/). Many of the smaller creeks and rivers flow into small ponds and lakes; as a consequence, this large volume of water from snowmelt can also cause a sudden rise in the water level of a pond or lake.

Snow begins to melt on the ice and adjacent land and pools on the ice. Areas of wet (saturated) snow are indicated by the arrows.

31.6 Mile Pond, AK on 19 April 2004.
(Photograph: Martin Jeffries)

As the snow melting accelerates, ponding occurs, this is, zones of standing water in the low lying areas of the ice cover appear (indicated by arrow).

31.6 Mile Pond, AK on 22 April 2005.
(Photograph: Martin Jeffries)

Rotten Ice

Rotten ice is any piece, body, or area of ice that is in the process of melting or disintegrating.
It is characterized by a honeycomb structure, weak bonding between crystals, or the presence of melt water between grains (Source: http://amsglossary.allenpress.com/glossary/).

One way that a lake or pond can break up is by in situ (in place) melting (thermal process).

After the snow melts, the white ice cover is exposed. Here is an example of spring ice cover on which hard, icy snow and snow ice are visible.

(Photograph: Martin Jeffries)

As the ice melts further, the black ice portion of the ice cover is exposed. Thermal cracks are clearly visible. The yellow field book is included for scale (12 x 19 cm).

(Photograph: Martin Jeffries)

As melting continues, water may pond on the surface of the ice and small areas of open water, in very shallow sections of the pond, may form.

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(Photograph: Martin Jeffries)

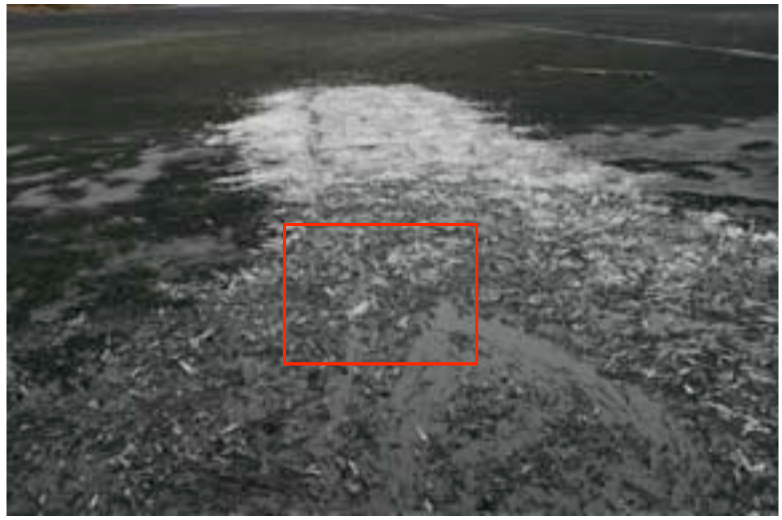
Advanced melting of the ice cover leads to a reduction in ice area, the formation of candle ice (see below), and disintegration of the ice cover.

(Photograph: Martin Jeffries)

Candle ice

Candle ice is a form of rotten ice. It is disintegrating river or lake ice consisting of ice prisms or cylinders oriented perpendicular to the original ice surface; these "ice fingers" may be equal in length to the thickness of the original ice before its disintegration (Source: http://amsglossary.allenpress.com/glossary/). Candle ice is formed when black ice melts in place; melting occurs along crystal boundaries perpendicular to the ice surface.

The long crystals of candle ice have the appearance of bundles of needles or "candles" hence its name. (Photograph: Martin Jeffries)



Candle ice is an intrinsically weak material that is easily broken. This is a candle ice cover that has been broken up by a shovel. (Photograph: Martin Jeffries)

This is a close-up of area in the box in the above image. It shows the elongated candle ice crystals. (Photograph: Martin Jeffries)

Moat

A **moat** is standing melt water on the ice cover, or open water, that encircles the pond or lake. This zone becomes a focus of subsequent ice disintegration.

Snowmelt, from the snow on the ice and the bank, forms a moat around the periphery of the pond on top of the ice. Energy can be transferred from the water to the underlying ice promoting melting.

(Photograph: Martin Jeffries)

Lake ice melts out around the edges of the pond/lake creating an open water moat. The heat radiated from the vegetation on the bank assists in this process.

(Photograph: Martin Jeffries)

This zone steadily expands as the ice melts from the top and the side. It can become an important stop over point for migrating waterfowl.

(Photograph: Martin Jeffries)

Once an open water area is established, it is possible for the ice to move on the pond in response to local winds, which often accelerates the disintegration of the ice cover.

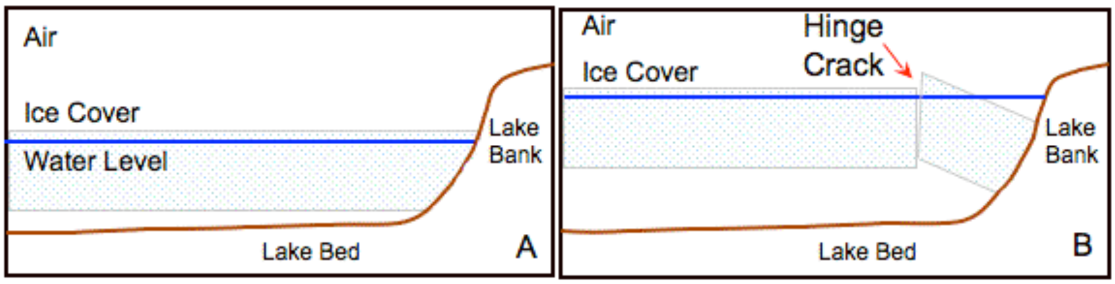
(Photograph: Martin Jeffries)

Hinge Cracks and Ice Cover Tipping

A **snowmelt flood** is a substantial rise in stream or river discharge caused by snowmelt runoff (Source: http://amsglossary.allenpress.com/glossary/). Many of the smaller creeks and rivers flow into small ponds and lakes; as a consequence, this large volume of water from snowmelt can also cause a sudden rise in the water level of a pond or lake.

A **hinge crack** is a crack caused by significant changes in water level (Source: http://www.expertglossary.com/weather/definition/hinge-crack). When a hinge crack forms in the spring ice cover, the ice is free to move in response to environmental forces.

Spring snowmelt can cause the water level in the pond to rise dramatically. The lake ice floats on top of the water (A). If the ice cover is not anchored to the lakebed or bank, it will freely rise with the increasing lake water level. However, if the ice is frozen to the lakebed (in shallow areas), the floating portion of the ice cover will flex and break forming a hinge crack (B).



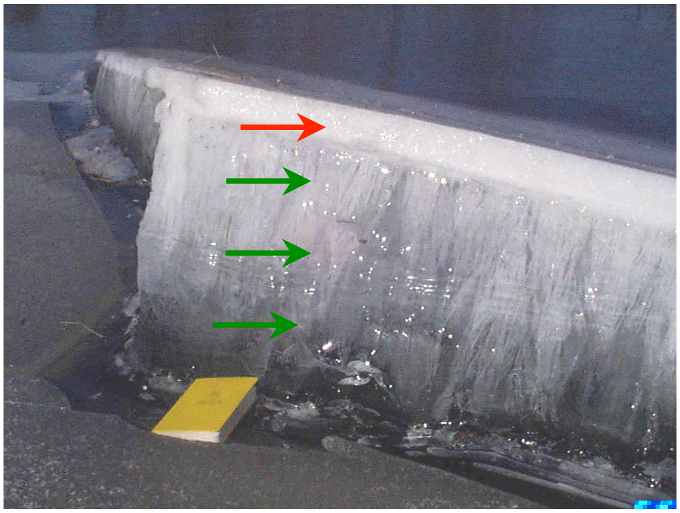
The hinge crack is indicated in the image below by the blue arrow. The ice at the left of this arrow is "free floating" at the new water level.

The orange arrow indicates a zone where the ice cover is frozen to the lakebed or bank. The ice is held in place below the new water level and water floods over the ice. The ice between the zone frozen to the lakebed and the hinge crack is "tipped" up.

(Photograph: Martin Jeffries)

The edge of the tipped ice face along the hinge crack, clearly shows the white (snow) ice and black (congelation) ice boundary.

The red arrow indicates the white (snow) ice. The green arrows indicate the black (congelation) ice. The black ice appears light grey (top) to dark grey (bottom). Note the vertical structure in the congelation ice. The field book is 12 x 19 cm.



(Photograph: Martin Jeffries)

These ice hinges can become one of the edges for ice blocks as the ice cover breaks up. These ice blocks can become stranded as the break-up proceeds (see below).

Ice Blocks

The ice cover can break up into large **ice blocks**. This will happen when thermal cracks and other ice cover flaws preferentially melt out because liquid water (snowmelt) drains into and eventually through them. Once the ice cover is weakened in this manner, and some open water is present, the wind can begin to move the ice cover around the pond causing further mechanical break-up.

On 2 May 2005, the ice cover has broken up into large blocks of ice. The ice blocks cannot move very much because there is little open water in the pond.

(Photograph: Martin Jeffries)

By 6 May 2005, the large ice blocks have broken up into smaller blocks. These blocks can be moved around the pond by persistent winds because the amount of open water has increased.

(Photograph: Martin Jeffries)

Stranded Ice Blocks

Large ice blocks can be stranded in shallow water or on another pieces of ice when the wind moves the ice from one end of the pond to the other and one piece of ice is forced underneath another.

(Photograph: Martin Jeffries)

Ice blocks can be stranded on the bank of the pond. This may happen when the lake water level falls rapidly. A rapid fall in water level may occur if an ice jam breaks and water is allowed to flow freely out of the pond.

(Photograph: Martin Jeffries)

Resources

These Alaska Lake Ice and Snow Observatory Network (ALISON) web pages provide some basic water and ice background:

- Background – Lake Ice Science: http://www.gi.alaska.edu/alison/ALISON_objective3.html
- Lake Ice And Snow Science: Why Study Lake Ice and Snow? Changes in Freshwater Ice http://www.gi.alaska.edu/alison/ALISON_SCIENCE_ChangeLakes.html
- Lake Ice and Snow Science – Basic Concepts: H_2O Phase Diagram http://www.gi.alaska.edu/alison/ALISON_SCIENCE_BConcepts.html
- Lake Ice and Snow Science – Basic Concepts: Hydrological Cycle
- http://www.gi.alaska.edu/alison/ALISON_SCIENCE_BC_H2OCycle1.html
- Lake Ice and Snow Science – Basic Concepts: Thermal Conductivity
- http://www.gi.alaska.edu/alison/ALISON_SCIENCE_BC_ThermCon.html
- Lake Ice and Snow Science – Basic Concepts: Albedo
- http://www.gi.alaska.edu/alison/ALISON_SCIENCE_BC_Albedo.html

The American Meteorological Society Glossary of Meteorology http://amsglossary.allenpress.com/glossary

Climate Change Project Jukebox - http://uaf-db.uaf.edu/jukebox/ClimateChange/htm/sam.htm#top
Samuel Demientieff's talk at the Annual OLGC Teachers Meeting December 2003 in Fairbanks has some pictures, definitions and observations about Global Change.

CRREL River Ice Guide and Glossary http://www.crrel.usace.army.mil/ierd/ice_guide/iceguide.htm

Expert Glossary http://www.expertglossary.com/science

MichiganTech – Geological & Mining Engineering & Sciences: Definitions of Lake Ice Terms
http://www.geo.mtu.edu/great_lakes/icegroup/ice_terms_jake.html

Nature Watch - Ice Watch: volunteer lake and river monitoring program in Canada.
http://www.naturewatch.ca/english/icewatch/

River Lake Ice Engineering, George D. Ashton (1986}